RESEARCH CIRCULAR 127 JANUARY 1964

SEDIMENTATION VALUES OF ARTIFICIALLY DRIED AND HEATED WHEAT

GLENN E. HALL

HAROLD K. HEIZER

OHIO AGRICULTURAL
EXPERIMENT STATION
Wooster, Ohio

Sedimentation Values of Artificially Dried and Heated Wheat

Glenn E. Hall* and Harold K. Heizer**

Wheat is often combine-harvested at moisture contents exceeding 16 percent. Such wheat, if marketed, will be graded "tough", and generally is not considered safe for storage.

Artificial drying is a means of reducing the excessive moisture content, and has become increasingly important. A preliminary investigation however, revealed that artificial drying alters the sedimentation value of soft red winter wheat. The purpose of this investigation then, was to study sedimentation value changes in a soft red winter wheat variety, Seneca, which was brought about by drying with heated air.

The sedimentation test is based on the volume change of flour particles, caused by absorption of water in the presence of lactic acid. The volume change is related to the quantity and quality of the gluten, and to other flour properties. The test value is obtained by measuring the volume of the dispersed flour after a specified imbibition period and settling time (3).

Pinckney, Greenaway, and Zeleny (2) modified the sedimentation test procedure to make it applicable to soft as well as hard wheat. In the modified procedure, the sedimentation test is performed on 200-gram samples. Highly significant correlations were consistently obtained between sedimentation values and bread loaf volumes. On the basis of large numbers of wheat samples over a 9-year period Pinckney, *et. al.*, suggested the following classification of wheat according to the sedimentation value:

1) Sedimentation values of 60 and above. This wheat generally consists of wheat having a protein content over 14 percent and superior bread baking properties.
2) Sedimentation values of 40 to 59. This wheat consists almost entirely of hard wheat, has a protein content between 12 to 14 percent, and is used for the production of bread flour.
3) Sedimentation values of 20 to 39. This wheat is best suited for the production of all-purpose flour or for a blend with stronger wheat for the production of bread flour.

*Department of Agricultural Engineering, Ohio Agricultural Experiment Station, Wooster, Ohio and, The Ohio State University, Columbus, Ohio.

**Soft Wheat Quality Laboratory, Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, Wooster, Ohio.

TABLE 1.–Grain Preparation Information

Phase	Harvest Moisture Percent	Wheat Protein 14 Percent Basis Percent	Crop Year	Moistute at Start of Drying Percent	Drying Time Range Minutes	Drying Temperature Range Degrees F	Sedimentation Test Date
1	27	11.6	1960	27	45-2900	85-220	Nov. 60
1	17	12.7	1960	17	25-2000	85-220	Nov. 60
1	13	12.9	1960	17	25-2000	85-220	Nov. 60
2	17	10.5	1961	17	20-1500	150-180	Feb. 62
3	13.5	10.5	1961	12.7	25, 65	130-250	Mar. 62
4	13.5	11.7	1962	11.7	0- 60	190	Oct. 62
5	13.5	11.7	1962	11.7	40	130-260	Oct. 62

4) Sedimentation values of 19 and below. This wheat consists almost entirely of soft wheat and is used primarily for the production of cake, pastry, cooky, and cracker flours.

EXPERIMENTAL PROCEDURE

Sample Preparation

The wheat drying and heat treatment was conducted in 5 different phases involving 3 crop years. Wheat moisture contents, air temperatures, and exposure times were used as parameters. Table 1 summarizes the various factors involved in the grain preparation for the 5 phases of the experiment.

The wheat in phases one and two was dried in an experimental drier (Figure 1) which had a separate air temperature controller in each of the the four stacks. A removable screen-bottomed container at the top of each stack held the wheat sample during drying. An airflow of 40 cfm through the 12-pound sample during drying was utilized. The samples were hand-stirred during drying, removed from the heated air stream when the sample had dried to about 13 percent moisture and cooled to room temperature. The wheat harvested at 13 percent in Phase 1 was rewet in a saturated atmosphere to 17 percent prior to the heated air exposure. The samples in Phase 2 were dried to 13 percent in the heated air stream and then exposed for an additional 1, 5, 12, and 24 hours in the same heated air stream. Subsamples containing 200 grams were taken from the 12-pound samples for the determination of the sedimentation value.

In phases 3, 4, and 5 of the wheat was heated in a smaller drier (Figure 2). An airflow of 20 cfm through the 200-gram sample was utilized. The sample was removed from the heated air stream after a specified time and cooled to room temperature.

Sedimentation Determination

The wheat samples were milled on a Quadrumat[1] mill which utilizes a break-action principle. Prior to milling, the samples were tempered to 14 percent moisture content. Flour yields of the samples averaged 65 percent on a tempered wheat basis. Sedimentation values were determined by the method of Pinckney, Greenaway, and Zeleny (2).

RESULTS

Tables 2 through 6 list the sedimentation values, on a 14 percent moisture basis, of all the replicates from the five phases of the experiment. In Tables 2 and 3 each listed value represents the mean of two sedimentation value determinations on each sample. In Tables 4, 5, and

[1]The mention of firm names or trade products does not imply that they are endorsed or recommended over those of other firms or similar products not mentioned.

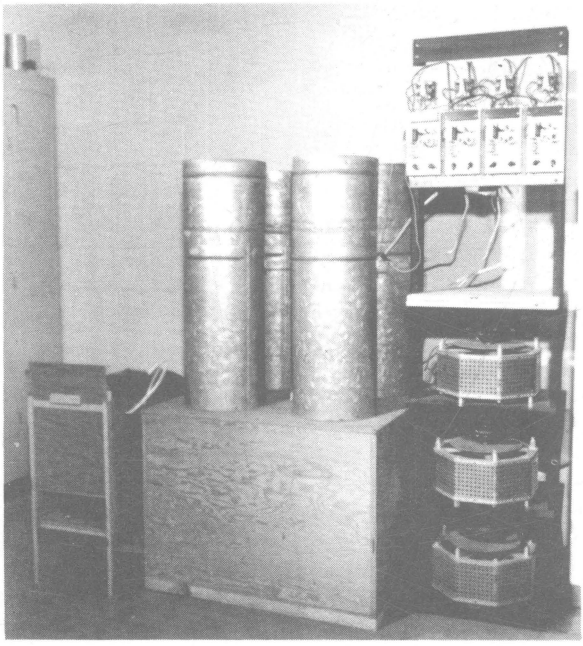

Fig. 1.—Laboratory drier used to dry the wheat in phases 1 and 2.

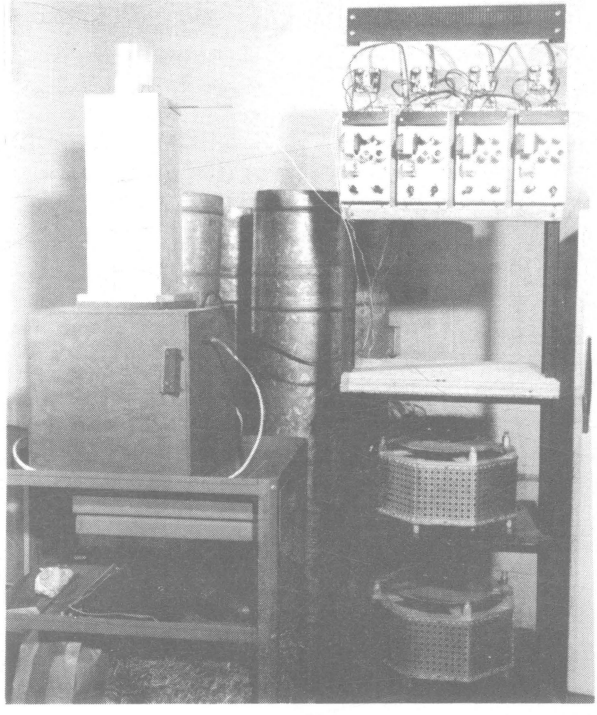

Fig. 2.—Laboratory drier used to expose the wheat in phases 3 through 5 to heated air.

6 each listed value represents the mean of 3 sedimentation value determinations on each sample. Each replicate represents a distinct sample from drying through testing.

Table 2, representing Phase 1, indicates the effect of various drying temperatures on the sedimentation value of wheat combine-harvested at 3 moisture levels. The 27 percent wheat increased in sedimentation value up to a drying temperature of approximately 190 degrees; above this temperature the sedimentation value decreased. The 17 and rewet 17 percent wheat increased in sedimentation value up to the highest temperature used, 220 degrees, and reached a maximum of about 39.4 cc. The wheat moisture content, as well as the air drying temperature, influenced sedimentation value. The lowest harvest moisture content resulted, generally, in the highest sedimentation value at any given drying temperature.

Drying temperatures above approximately 160 degrees denature flour proteins in wheat containing 17 to 20 percent moisture (1). Quality and volume of biscuits and bread baked with 17 and rewet 17 percent moisture wheat from Phase 1 were maintained at temperatures up to 160 and decreased above this temperature. This same phenomenon occurs at a drying temperature of 130 degrees for wheat at 27 percent moisture. Drying temperatures of 160 and 130 degrees appear to be the break points in the curves where the sedimentation value begins to increase more rapidly with temperature. To determine the effect of drying time about this point for 17 percent wheat, 3 drying temperatures, 150, 160, and 180 degrees, were used to dry the wheat to 13 percent. Continued exposure to the drying air, beyond the time necessary to dry 13 percent, for 1, 5, 12, and 24 hours, representing Phase 2, reduced the sedimentation value, as shown in Table 3. While sedimentation value reduction at

TABLE 2.–Wheat Combined at Various Moisture Contents and Dried at Temperatures from 85° to 220°.

Drying Temperature, °F	Moisture Content, Percent		
	17	27	Rewet 17
85	30.0	27.4	30.8
130	31.0	27.9	33.0
150	30.3	30.8	
160	30.1	38.0	31.9
175	33.0	32.5	
190	33.7	32.9	
220	39.3	27.0	39.5
Control	30.0	30.0	30.0

TABLE 3.–Wheat Combined at 17 Percent Moisture, Dried to 13 Percent, and Exposed to the Drying Air for Various Periods of Time.

Drying Temperature, °F	Replicate	Exposure Time, Hours				
		0	1	5	12	24
150	1	20.3	20.0	19.9	19.1	20.5
150	2	23.0	22.0	22.0	20.8	20.5
150	3	21.3	20.5	22.5	19.8	21.3
160	1	20.0	20.5	21.4	20.7	20.7
160	2	23.3	23.3	22.0	21.8	19.8
160	3	22.5	23.0	22.5	23.3	23.0
180	1	25.8	26.0	24.6	24.3	23.3
180	2	26.5	26.0	23.0	23.5	23.5
180	3	25.5	27.2	26.0	25.5	25.0

TABLE 4.–Wheat Combined at 13½ Percent Moisture and Exposed to Air Heated to Various Temperatures for 25 and 65 Minutes.

Exposure Temperature, °F	Exposure Time, Minutes			
	65 Replicate		25 Replicate	
	1	2	1	2
130	20.8	18.8	20.5	20.0
160	18.3	21.0	20.5	17.8
190	25.5	24.7	29.0	29.0
220	24.5	25.3	27.0	27.0
250	12.0	11.5	8.8	5.5
Control	20.0	18.0	20.0	18.0

TABLE 5.–Wheat Combined at 13½ Percent Moisture and Exposed to 190° F Heated Air for Various Periods of Time.

Replicate	Exposure Time, Minutes					
	10	20	30	40	50	60
1	34.3	35.9	35.3	36.3	33.9	35.3
2	33.4	33.8	35.2	35.4	35.6	35.2
Control	28.7	29.1				

TABLE 6.—Wheat Combined at 13½ Percent Moisture and Exposed to Air Heated to Various Temperatures for 40 Minutes.

	Exposure Temperature, °F													
Replicate	130	140	150	160	170	180	190	200	210	220	230	240	250	260
1	28.3	27.2	28.4	28.8	29.0	34.2	36.7	40.3	42.0	37.7	31.0	22.5	18.7	14.8
2	28.6	29.3	28.0	27.9	29.8	31.8	38.2	42.0	41.3	36.1	31.4	20.3	17.3	14.8
3	26.4	28.6	28.5	27.2	28.1	30.9	34.9	40.7	41.8	35.9	28.9	21.8	17.3	14.6
Control	26.7	27.8	27.3											

the 150 and 160 degree drying temperatures was not statistically significant, the lower value at the 180 degree temperature was significant. Time zero in Table 3 would be the time at which the wheat would have dried to 13 percent moisture at the various temperatures and would represent the beginning of "overexposure".

Figure 3 and Table 4 represent Phase 3 and indicate the sedimentation values of the control wheat and of samples exposed to air temperatures of 130, 160, 190, 220, and 250 degrees for drying times of 25 and 65 minutes. The shorter exposure time yielded higher sedimentation values at a temperature of about 190 degrees, which was the peak value of both curves. The 250 degree temperature produced values considerably below the initial value. The increase in the sedimentation values with increasing temperatures up to about 190 degrees was highly significant and reflects the effect of time and temperature. Figure 4 and Table 5, which represent Phase 4, indicate the sedimentation value of wheat combine-harvested at 13.5 present moisture and exposed to 190 degree heated air for various periods of time. The sedimentation value reached a maximum after approximately 40 minutes exposure. Figure 5 and Table 6 represent Phase 5 and indicate the sedimentation value of wheat combine-harvested at 13.5 percent moisture and exposed to various heated air temperatures for 40 minutes. The sedimentation value increased directly with the air temperature from 160 to about 210 degrees and then decreased at the higher temperatures. The change in the sedimentation value from 160 to 220 degrees represents an increase of approximately 50 percent.

Table 7 lists the level of significance of the variables and the least significant difference at the 0.05 level of probability for the sedimentation values for phases 2 through 5. The work in Phase 1 was not replicated and could not be statistically analyzed.

TABLE 7.–Statistical Summary of Sedimentation Determination.

Phase	Variable	Significance	Sedimentation Value L.S.D.05[3]	Number of Replicates
2	Drying Temperature	**[1]	0.9 cc.	3
2	Exposure Time	n.s.[2]	1.2 cc.	3
3	Exposure Temperature	**	3.0 cc.	2
4	Exposure Time	**	1.5 cc.	2
5	Exposure Temperature	**	1.7 cc.	3

[1]Significant at the 0.01 level of probability.

[2]Not significant.

[3]Difference required for significance at .05 level.

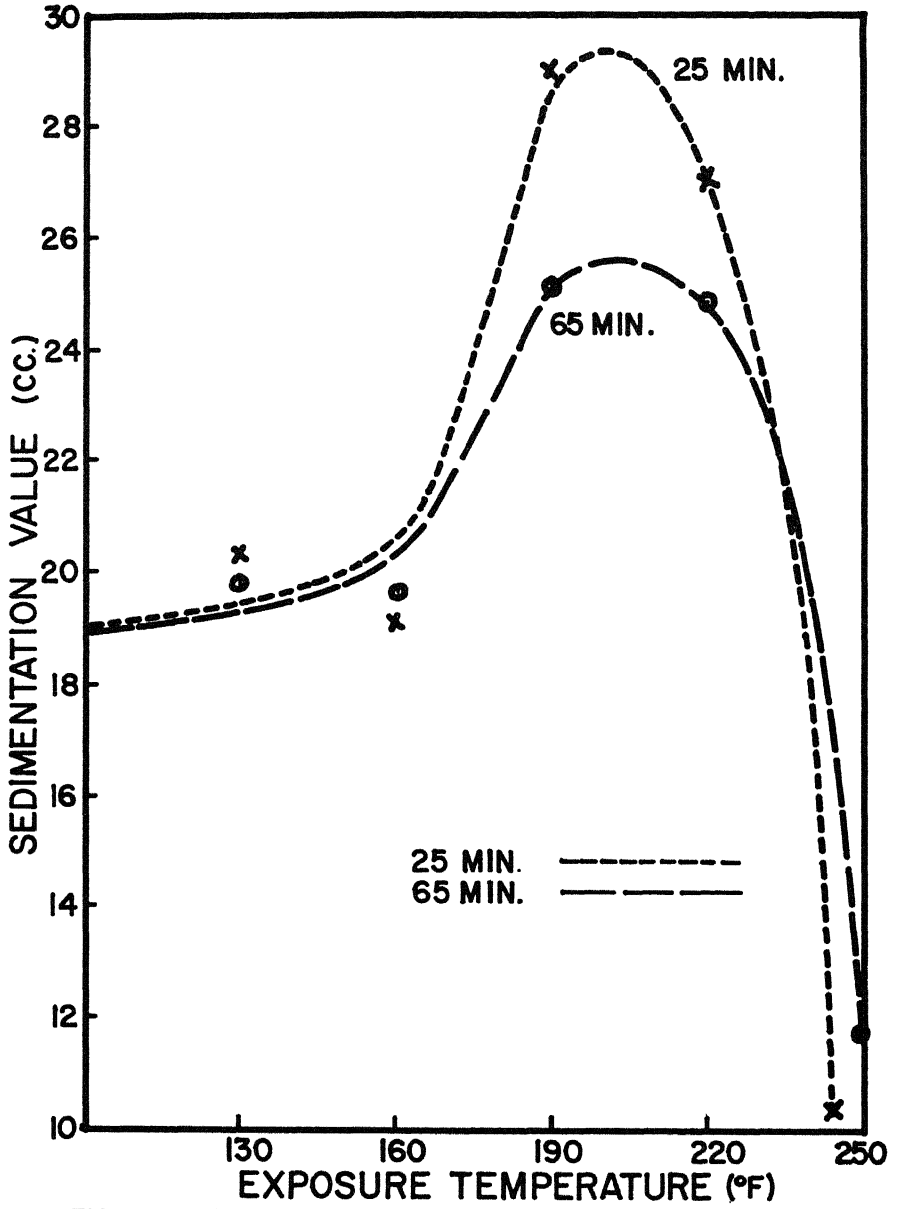

FIG. 3 — SEDIMENTATION VALUES OF WHEAT COMBINED AT 13 1/2 % MOISTURE AND EXPOSED TO AIR HEATED TO VARIOUS TEMPERATURES FOR 25 AND 65 MINUTES

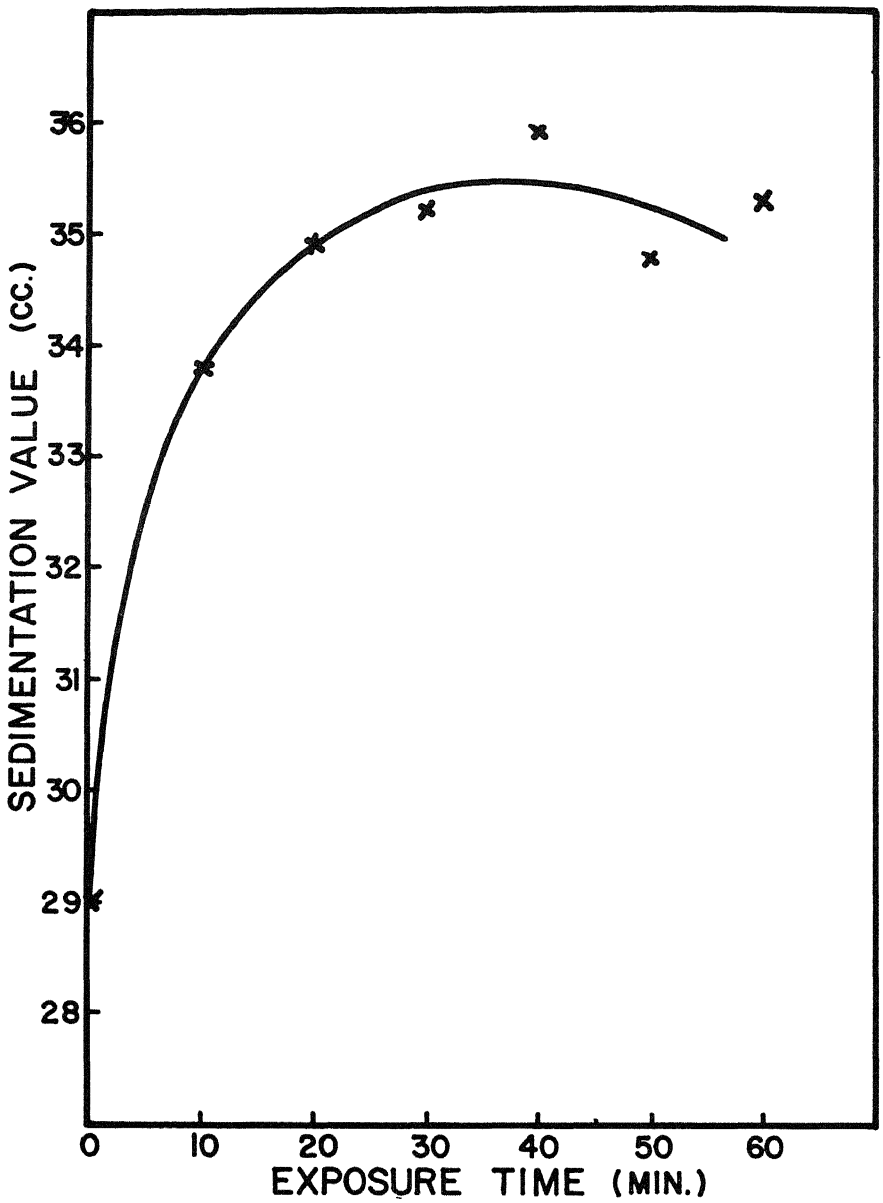

FIG. 4 — SEDIMENTATION VALUES OF WHEAT COMBINED AT 13 1/2 % MOISTURE AND EXPOSED TO 190° F HEATED AIR FOR VARIOUS PERIODS OF TIME

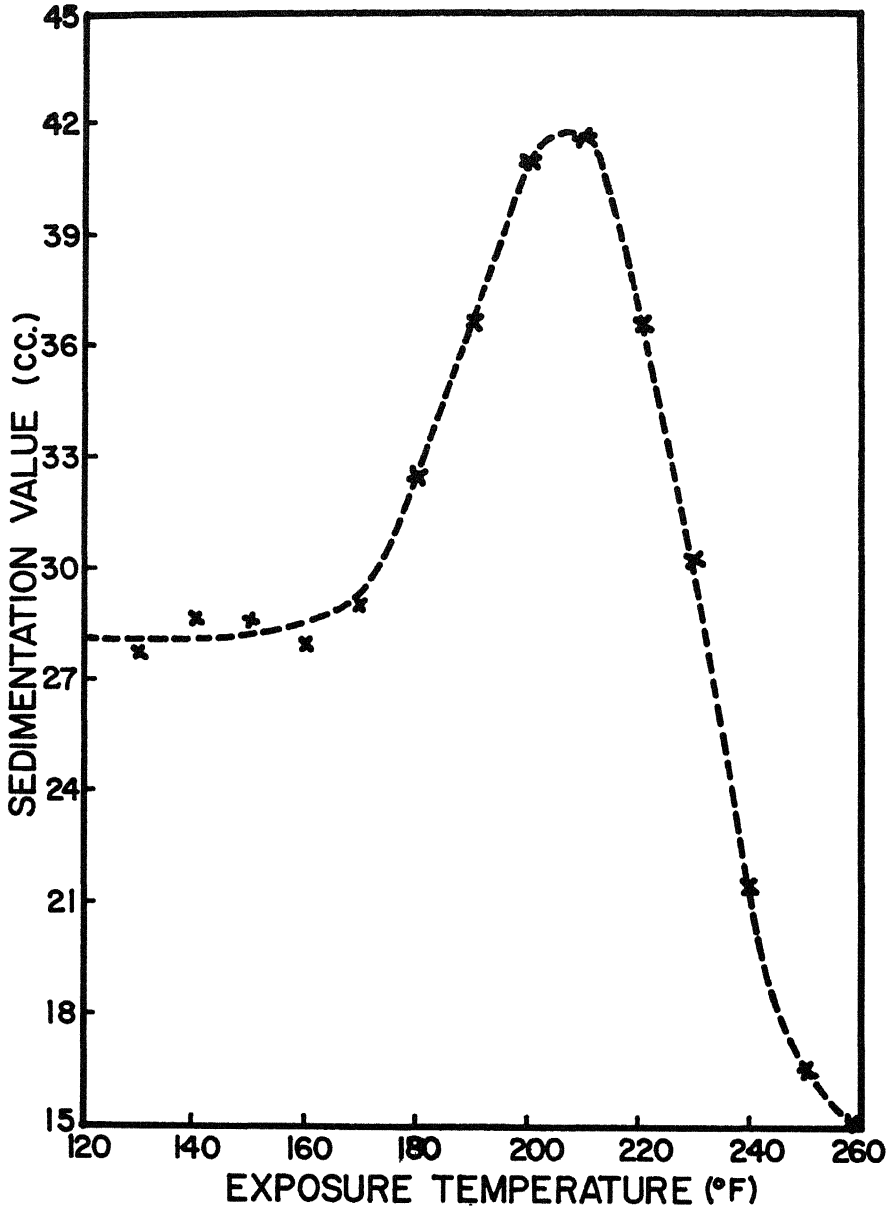

FIG. 5 — SEDIMENTATION VALUES OF WHEAT COMBINED AT 13 1/2 % MOISTURE AND EXPOSED TO AIR HEATED TO VARIOUS TEMPERATURES FOR 40 MINUTES

SUMMARY

Research involving a 3-year study of the effect of exposure to heated air for drying Seneca soft red winter wheat indicated that the sedimentation value was affected by heated air. Wheat combine-harvested at 17 percent moisture or less attained a maximum sedimentation value when the wheat was exposed to heated air in the range of 190 to 220 degrees F. Wheat combined at 27 percent moisture reached a maximum sedimentation value at a drying temperature of about 190 degrees. Bread and biscuit baking with wheat which had been dried from 27, 17, and rewet 17 percent moisture to 13 percent indicated that the flour protein was damaged at drying temperatures above 130 and 160 degrees for 27 and 17 percent wheat, respectively. These data indicated that the sedimentation test was not a good indicator of the baking potential of wheat which had been air dried at temperatures exceeding 160 degrees F.

The exposure of 17 percent moisture wheat to the drying air (at 180°) beyond the time necessary to dry the wheat to 13 percent significantly decreased the sedimentation value; at 150 and 160 degrees the value was decreased slightly by overexposure.

The sedimentation value of wheat combine-harvested at 13.5 percent moisture and exposed to 210 degree heated air for 40 minutes showed a highly significant change from approximately 28 to 41 cc.

REFERENCES

(1) Hall, G. E., High Temperature Wheat Drying, Ohio Farm and Home Research, July-August 1963.

(2) Pinckney, A. J., Greenaway, W. T., and Zeleny, L., Further Developments in the Sedimentation Test for Wheat Quality, Cereal Chemistry, Vol. 34, pp. 16-25, January 1957.

(3) Zeleny, L., A Simple Sedimentation Test for Estimating the Bread-Baking and Gluten Qualities of Wheat Flour, Cereal Chemistry, Vol. 24, pp. 465-75, November 1947.